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# **“Astaneh-Black” Steel Single Tower Curved Bridge**

Proposed for the East Bay Crossing of the San Francisco- Oakland Bay Bridge

Designers:

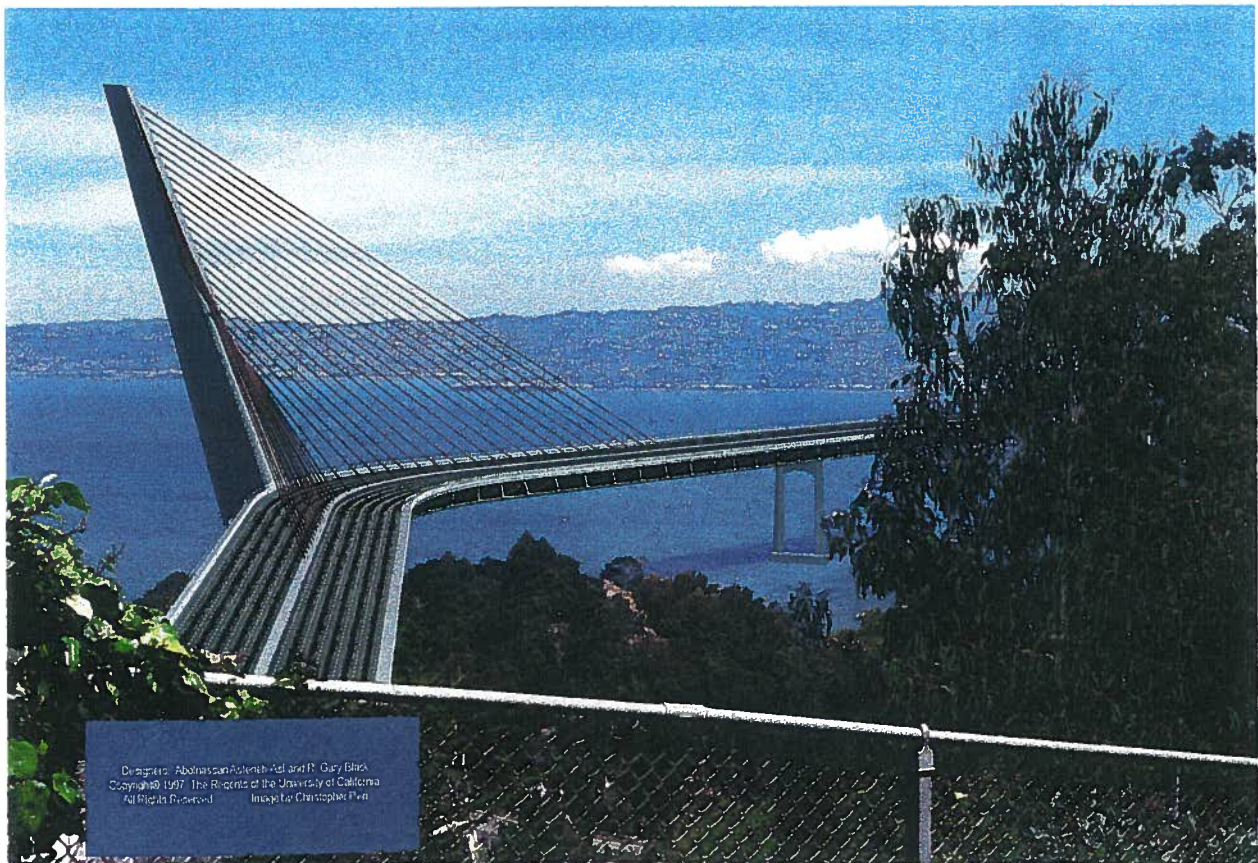
**Abolhassan Astaneh-Asl, Ph.D., P.E. & R. Gary Black, M. Arch., P.E.**  
Professor of Civil Engineering      Associate Professor of Architecture

University of California, Berkeley

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**Submitted to the Engineering and Design Advisory Panel (EDAP) of  
The Metropolitan Transportation Commission's Bay Bridge Design Task Force  
Supervisor Mary King, Chair  
May 6, 1997**



# **“Astaneh-Black” Steel Single Tower Curved Bridge**

Proposed for the East Bay Crossing of the San Francisco- Oakland Bay Bridge

## **Designers:**

Abolhassan Astaneh-Asl, Ph.D., P.E.  
Professor of Civil Engineering

&

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Associate Professor of Architecture  
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## **INTRODUCTION**

The 1989 Loma Prieta earthquake caused widespread damage to transportation facilities. In the aftermath of the quake, a team of University of California faculty and students led by Professor Abolhassan Astaneh conducted a comprehensive seismic study of the East Bay Crossing of the San Francisco Oakland Bay Bridge for Caltrans. Results of the study summarized in a report to Caltrans in 1992 identified areas of seismic vulnerability and suggested seismic retrofit strategies. Later, Caltrans conducted an in-house design of seismic retrofit. Early this year, the State announced that seismic retrofit of the east spans of the Bay Bridge as well as replacing it will cost about \$1.0 billion.

To review the issues related to a retrofit or replacement bridge, and to make recommendations to the State on the type of replacement bridge, a Bay Bridge Design Task Force was formed. The Task Force, chaired by Supervisor Mary King has formed an Engineering and Design Advisory Panel (EDAP) to assist the Task Force in recommending a preferred design for a new eastern span of the Bay Bridge. Our proposed new design explained in the following sections is submitted for consideration and presentation at the EDAP May 12-14 Workshop.

## **PROPOSED “ASTANEH-BLACK” STEEL SINGLE TOWER CURVED BRIDGE**

As an Initial Submittal, in the following the conceptual design of our proposed bridge and the key structural features are provided. More detailed information will be provided at the Workshop.

### **A. Engineering Aspects:**

The location of the proposed bridge, as well as the connection to Yerba Buena Island and the alignments, are shown in the attached Drawing AB-1. The proposed bridge consists of two parts: (I) a 2,040 feet long steel single tower, curved cable stayed bridge with its single tower on the Yerba Buena Island and (ii) a 7,000 feet long causeway connecting the cable stayed bridge to the Toll Plaza on the Oakland shore.

The super-structure of the proposed bridge is mainly a curved multi-cell steel box girder supported by the cable stays and a single sloped tower as shown in the attached Drawings AB-2 and AB3. The roadway is a lightweight reinforced concrete slab supported on stringers and floor beams. The superstructure has three articulated supports; one at the location of tower and two at the location of the end piers. The articulation of the supports will be discussed in the Workshop Submittal.

The static and dynamic analyses conducted indicate that the behavior of the structure under gravity, wind, earthquakes and combined effects of these loads is very stable and desirable. The flutter and vortex shedding effects due to wind are insignificant. This is primarily due to the use of streamlined cross section of the steel box and the tri-pod nature of the curved structure on three supports.

The tower, at this conceptual stage, is considered to be a steel composite section. The single tower is located on the solid rock of the Yerba Buena Island. The foundation of the tower is inside the rock. As a result, the cost of construction of the foundation as well as seismic ground motions are very low.

The steel used for the bridge will be high-performance weathering steel. Weathering steel has been used successfully since 1960's throughout the US including California. This type of steel does not need painting. However, if the outside surface is painted for aesthetic reasons, the cost of painting the bridge every 40 years or so will be considered in the final cost estimate. The high-performance weathering steel has a higher strength than the regular steel and more importantly is more ductile. The higher strength results in cost efficiency and the high ductility leads to an excellent seismic performance of the bridge.

By choosing steel as the primary material for our bridge we have guaranteed superior seismic performance of the bridge as was proven during the recent earthquakes particularly during the 1995 Kobe-Japan earthquake. In addition, we have achieved the following advantages:

- The flexibility of steel enables a graceful curved design and sloped tower for an elegant appearance and a reliable structural and seismic performance.
- The curved design results in a shorter bridge length saving in cost of construction, maintenance and the gas and time spent by drivers through the 150 years design life of the bridge. The shorter length also reduces the environmental disturbance of the Bay.
- The light weight of the proposed bridge, 50% less than comparable concrete designs, results in considerable saving in the cost of construction as well as reducing the seismic forces.
- High-performance weathering steel, used in our proposed bridge, provides protection against corrosion and eliminates the need for painting. Any painting of outside surfaces for aesthetic reasons will last for at least forty years and possibly longer in the East Bay environment.

## **B. Architectural Aspects**

The single tower, cable-stayed bridge is meant to be consistent with, and pay homage to, the Golden Gate Bridge and the West Bay Crossing of the San Francisco-Oakland Bay

Bridge, by being a tower and cable bridge. At the same time, it is a visually memorable landmark and acts as a gateway to Oakland and other cities of the East Bay. In this respect it must be different from these bridges -- being to the turn of the millennium what the Golden Gate Bridge and the West Bay Crossing of the Bay Bridge are to the first part of the Twentieth Century.

The curved deck is suspended by cable stays from a tower which is raked to balance the forces -- both structurally and visually -- of the weight of the deck and the traffic. The bridge takes the concept of the suspended decks of the Golden Gate Bridge and West Bay Crossing of the Bay Bridge and extends it to another dimension. In these existing bridges the cables work in two dimensions to pull the forces up and over to the foundations and land masses so that they can be transferred to the earth. In the curved bridge, the forces pull the cables in three dimensions -- upward, over to the tower and back -- acting as a rein on the bridge deck. The architecture of the bridge expresses exactly what is occurring structurally.

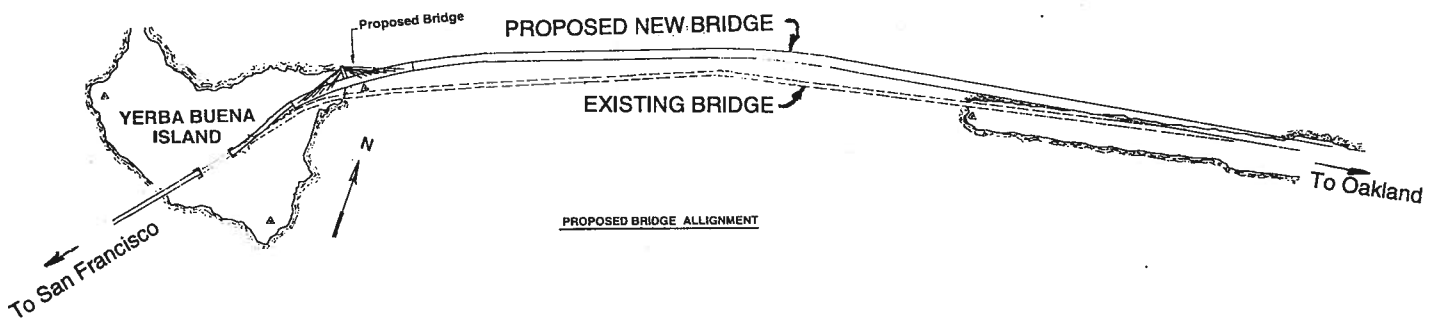
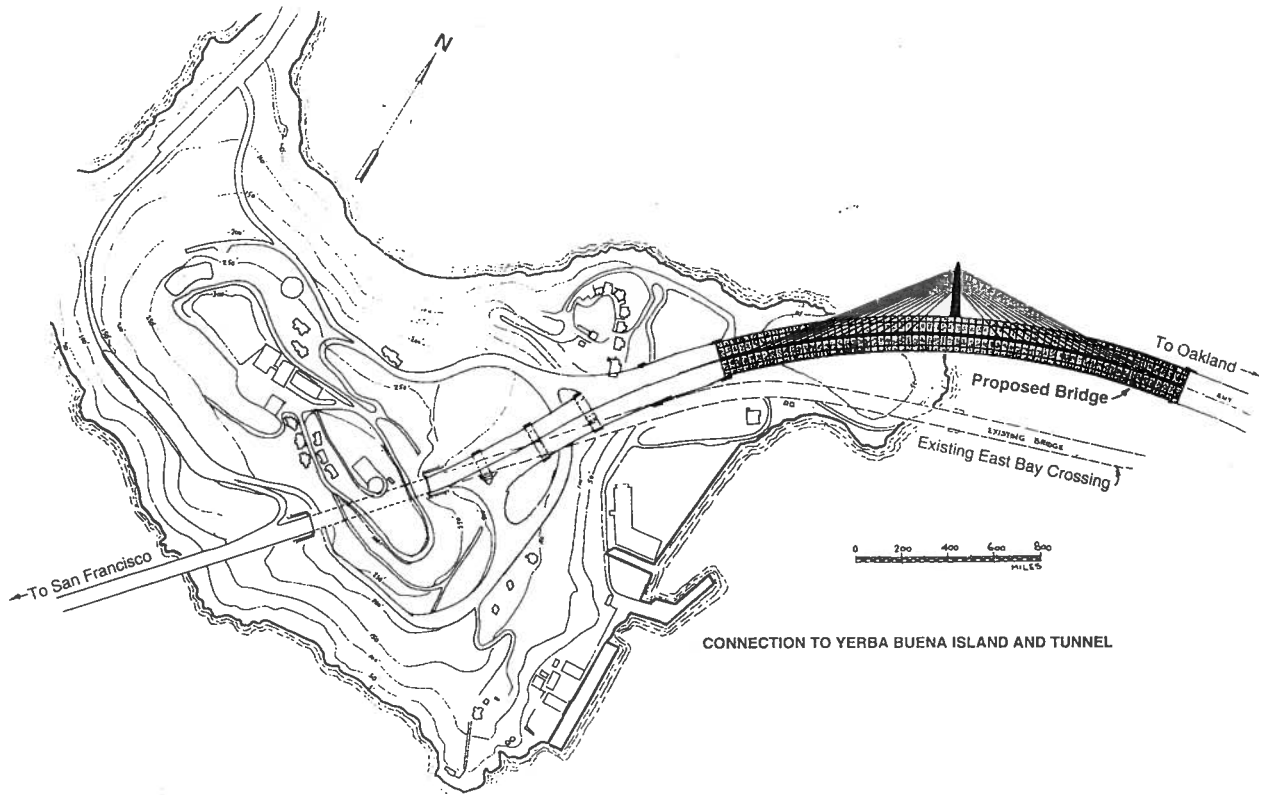
The bridge deck includes a bicycle path and pedestrian walkway. Guardrails and handrails are designed to provide transparency to a moving vehicle.

### **C. Environmental Aspects**

The curve of the bridge at the Yerba Buena Island side is mandated by the environmental concerns. Having the curve at this section enables us to align the bridge roughly parallel to the existing bridge. This feature has two advantages: (I) it allows us to shorten the length of the bridge (by more than 1000 feet over the Caltrans proposals) considerably saving on construction costs, gas and the time spent on the bridge by users; and (ii) it also lessens the area on the bed of the Bay that suffers environmental effects as the new bridge is built and the old bridge demolished.

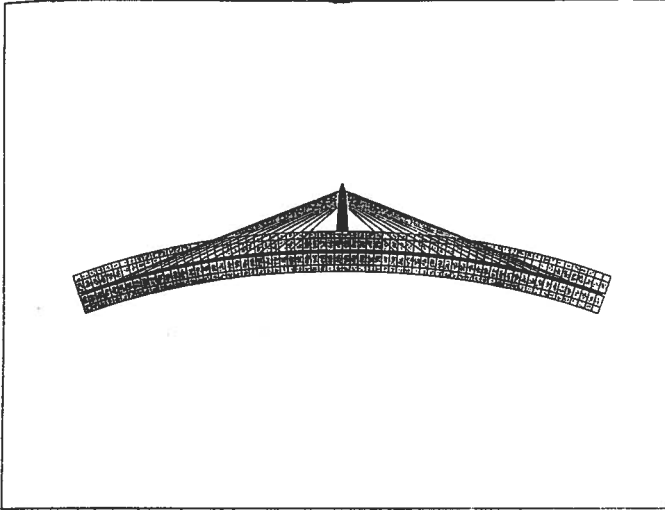
### **Acknowledgment:**

The analyses conducted for this proposal were done using the latest version of SAP2000 program provided to the team by Computers and Structures Inc. of Berkeley free of charge.



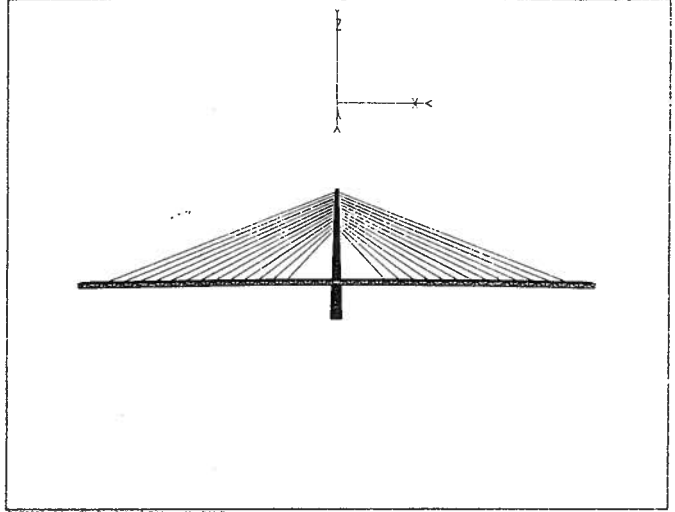
<p align="center"><b>"ASTANEH-BLACK" Steel Single Tower Curved Bridge</b> for the East Bay Crossing of the San Francisco-Oakland Bay Bridge</p>				
<p align="center">Designed by:  <b>Abolhassan Astaneh-Asl, Ph.D., P.E.</b> and <b>R. Gary Black, M. Arch. P.E.</b>          Professor of Civil Engineering      Assoc. Professor of Architecture</p>				
<p align="center">Copyright ©, The Regents of the University of California, All Rights Reserved.</p>				
<p align="center"><b>LOCATION AND CONNECTION TO THE YERBA BUENA ISLAND</b></p>				
Designed by: A. A.	Checked by: S. C.	Traced by: A.A.	Date: 5/ 5/97	DRW. No. <b>AB--1</b>

SAP2000

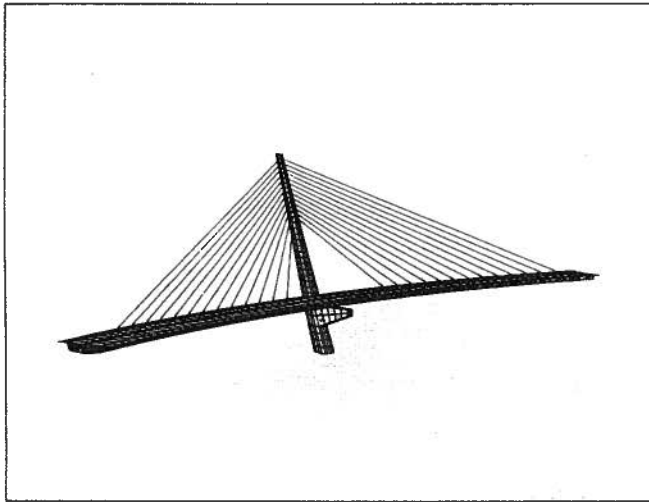


SAP2000 v6.04 - File:Sym3\_1c - Deformed Shape (DEAD) - Kip-ft Units

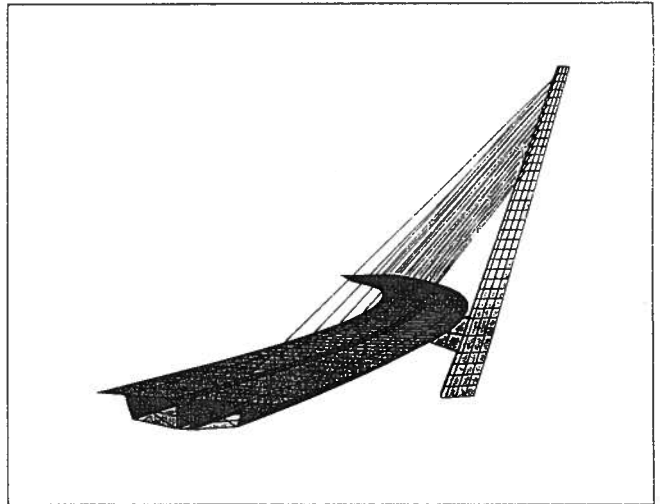
SAP2000



SAP2000 v6.04 - File:Sym3\_1c - 3-D View - Kip-ft Units



SAP2000 v6.04 - File:Sym3\_1c - 3-D View - Kip-ft Units



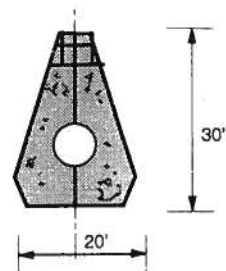
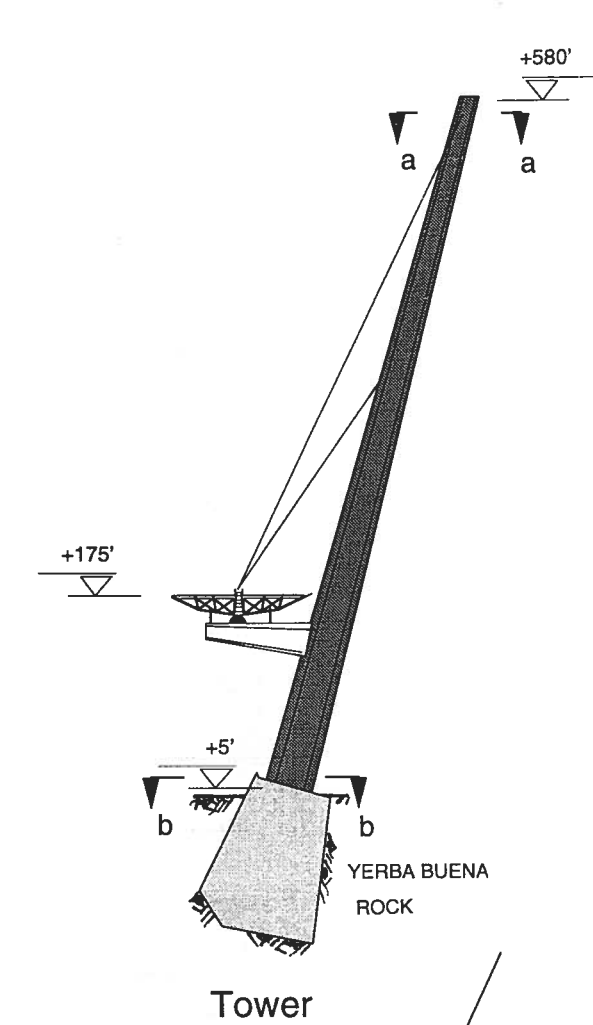
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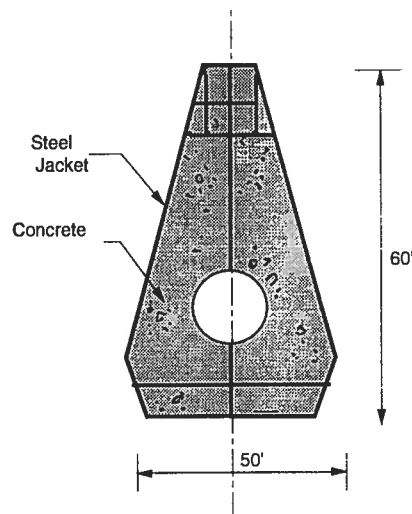
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**STRUCTURE OF THE BRIDGE**

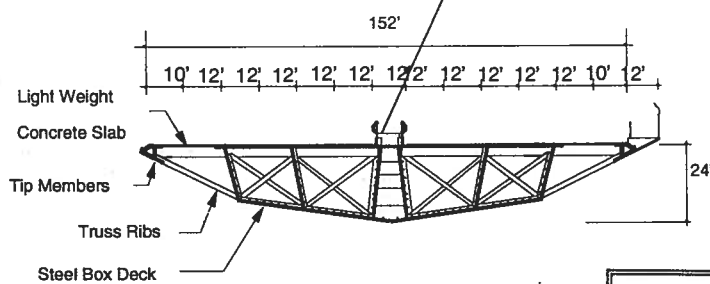
Designed by: A. A.	Checked by: S. C. and M.H.	Traced by: A. A., S. C. & M. H.	Date: 5/5/97	DRW. No. AB-2
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Section a-a



Section b-b



Tentative Deck Section

**"ASTANEH-BLACK" Steel Single Tower Curved Bridge**  
for the East Bay Crossing of the San Francisco-Oakland Bay Bridge

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Professor of Civil Engineering Assoc. Professor of Architecture

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### STRUCTURAL DETAILS OF THE BRIDGE

Designed by: A. A.	Checked by: S. C. and M. H.	Traced by: A. A., S. C. & M. H.	Date: 5/5/97	DRW. No. <b>AB-3</b>
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721 DAVIS HALL  
BERKELEY, CALIFORNIA 94720-1710  
TEL. 510/642-6463 FAX 510/643-8928

Mr. Steve Heminger  
Project Manager  
Metropolitan Transportation Commission  
101 Eight Street  
Oakland, CA 94607

Dear Mr. Heminger:

Enclosed please find 50 copies of our Initial Submittal for the "Astaneh-Black" proposed design of replacement for the East Bay Crossing of the San Francisco-Oakland Bay Bridge. Our proposed design satisfies all Engineering and Design Criteria provided in Attachment 2 of your memorandum of April 29, 1997.

We are preparing the Workshop Submittal and are ready all three days of May 12-14, 97 to participate in the Workshop, to present our proposed design and to answer questions.

If you have any questions or comments please do not hesitate to contact me at:

Abolhassan Astaneh  
781 Davis Hall  
University of California  
Berkeley, CA 94720-1710  
Phone: (510) 642-4528, Fax: (510) 643-5258  
e-mail: [astaneh@ce.berkeley.edu](mailto:astaneh@ce.berkeley.edu)

Respectfully,

A handwritten signature in black ink, appearing to read "Abolhassan Astaneh".

Abolhassan Astaneh,  
Professor